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THE ARMATURE OF LAND MOLLUSCA.

THE subject on which I venture to address you to-night has been a favourite study with me for a considerable number of years. My interest in these structures was first aroused through the receipt of some specimens of *Corilla* from Ceylon, on which I based a new species. The Editor of *Science Gossip* having in 1896 requested me to contribute some articles on Mollusca, I chose the "Armature of Helicoid Land Shells" as my subject, which, however, was side-tracked into what amounts practically to a monograph of the genera *Corilla* and *Plectopylis*.

On that occasion I drew attention to the fact "that Mollusca have numerous enemies is well known to naturalists, for not only do they serve as food for many mammals, birds, and reptiles, but they are preyed upon by some insects, and even by other mollusca. Naked slugs are especially exposed to the attacks of birds, slow-worms, and snail-slugs (*Testacella*), and, in foreign countries, of carnivorous snails, such as *Glandina* and others. Shell-bearing Mollusca likewise are devoured by birds and mammals; they have besides many insect enemies, particularly in tropical climates, and we shall, therefore, not be surprised to find that in several instances these creatures have come to be provided with special means of protection. This has been attained in various ways, indirectly by protective resemblance between the forms or colours of the shells and their immediate surroundings; or directly by special structures, such as teeth, plates, or constrictions, serving as buttresses or barricades behind which the animal can withdraw. It is probable, however, that these structures may at the same time help to strengthen and support the outer wall of the shell".

That structures of this nature serve as a means of defence against the attacks of carnivorous insects and similar creatures was suggested as long ago as 1829 by Guilding,¹ who, in speaking of the teeth and laminae of the Pupidæ, observed that "they may answer the purpose of an operculum to keep out enemies, while they afford no obstacle to the motion of the soft and yielding body of the animal".

Of much interest in this connection is a note by Lieut.-Col. Godwin-Austen, who, in a paper on the genus *Plectopylis*, states that "when breaking up a number of shells to expose the barriers and ascertain if their characters were constant, I was greatly interested to find in two instances the presence of small insects that had become fixed between the teeth".²

¹ Zool. Journ., vol. iv, 1829, p. 168.

² Proc. Zool. Soc., 1874, p. 611.

During my investigation of these armatures in *Corilla* and *Plectopylis* I discovered that in most cases the barriers in immature shells differed considerably from those found in full-grown ones, more especially in those of *Corilla*, while in one case, i.e. *Corilla adamsi*, these protective structures occur only in the immature shells, the animal dispensing with them entirely on completing the shell. Without knowing the actual conditions in its surroundings it is, of course, impossible to account for this phenomenon, but it may be surmised that the absence of predatory insects may have produced this result, and that the formation of the barriers in immature shells is simply the survival of an ancestral character. Two other forms of protective structures, even more efficacious, are found (*a*) in the members of the genus *Clausilia*, which produce the elastic shutter, or clausilium, and (*b*) the numerous operculate genera, whose members are provided with a lid, or operculum, completely closing the shell.

The first group to be considered in detail is the family of TESTACELLIDÆ, subfamily STREPTAXINÆ.

Genus STREPTAXIS, Gray.

This genus ranges through South and South-Eastern Asia, the Mascarene Islands, tropical Africa, and South America. Several species are devoid of armature, such as the helicoid forms: *S. wagneri*, Pfr., and *S. apertus*, Mts., from Brazil, and elongate ones such as: *S. contusus*, Fér., from Brazil, *S. dacosta*, Gude, from Colombia, and *S. nobilis*, Gray, from Liberia. In the simpler forms, such as *S. burmanicus*, Blanf., from India, *S. pfeifferi*, Zel., and *S. andamanensis*, Bens., from the Nicobar and Andaman Islands, only a raised, entering, parietal lamella is found, but the majority of species have complicated obstructions at the aperture. For instance, *S. theobaldi*, Blanf., from the Khasi Hills, has two raised lamellæ on the parietal callus, three on the basal lip and three on the outer lip of the peristome, while *S. paulus*, Gude, a Chinese form, has two of the parietal callus, two on the basal and two on the outer lip of the peristome. A curious helicoid form, *S. roebelini*, Mlldff., from the Samui Archipelago, has a raised lamella on the parietal wall and three palatal teeth; this species belongs to the section *Odontartemon*.

The genus *Systrophia*, Alb., confined to South America, is not provided with teeth, but the parietal callus is raised into a curved plate, in some species, such as *S. systrophia*, Alb., from Bolivia, closely approaching the upper and lower lip of the peristome, leaving only a narrow slit for the animal to protrude; there is besides a constriction behind the peristome. In *S. cheilostropha*, Orb., a Brazilian species, there are in addition two denticles, one on the upper and one on the lower lip of the peristome.

In *S. reyrei*, Souv., from Ecuador, the parietal callus is only slightly raised, but within, nearly one-quarter of a whorl behind the peristome,

occur four denticles, two on the parietal and two on the palatal wall. Again, *S. heligmoidea*, Orb., also from Ecuador, has the parietal callus raised and furnished with a compressed fold, which is continued for some distance on the parietal wall and coincident with a tubercle on the upper palatal margin of the peristome corresponding with a scrobiculation, the aperture being in consequence sub-triangular.

Genus ENNEA, H. & A. Adams.

This has a wide distribution, being found throughout southern and south-eastern Asia from Arabia to Japan and the Philippine Islands; Madagascar, the Mascarene Islands, and throughout tropical and southern Africa.

E. mucronata, Mts., a Cameroon species, is provided with an entering, flexuous fold on the parietal wall near the upper part of the peristome, which bears a corresponding tubercle, while on the outer lip are found two flexuous, entering folds, and the columella bears a flexuous, entering fold, bidentate at the anterior end. *E. ringens*, H. Ad., from Sierra Leone, has a parietal lamina, three profound columellar teeth, and several lamellæ within the outer lip, four of which are longer and more prominent than the others. *E. infrendens*, Mts., a Natal species, has its aperture nearly closed, having a raised, compressed lamella at the parietal angle, a deep-seated, bipartite, columellar plica, two small teeth on the basal margin, and two on the palatal margin of the peristome, the upper one being the larger. *E. planti*, Pfr., another Natal form, possesses a slight, entering, flexuous fold on the columella, one short, compressed lamina on the parietal wall near the insertion of the upper margin of the peristome.

The next group for consideration is the family ZONITIDÆ.

Genus VITREA, Fitz.

Of this genus, which has a very wide distribution, only a few of the North American species are provided with armature. *V. interna*, Say, has two prominent sub-lamelliform white teeth, which do not reach the edge of the peristome. Several other species have radial series of internal teeth on the lower wall of the last whorl. In *V. multidentata*, Binn., some specimens have these teeth united at their base into barriers, these processes being distinctly visible through the thin shell-wall.

Genus GASTRODONTA, Albers.

This is confined to North America, and its members have more solid shells than those of the last genus dealt with. *G. gularis*, Say, has a long, revolving fold inside on the base of the last whorl, extending for about two-thirds of a whorl; some have a strong, raised denticle on the basal margin of the peristome. Immature shells show two folds. *G. lasmodon*, Phill., is provided on the base with two, nearly

parallel, prominent, deeply entering, revolving, white lamellæ; on the other hand, *G. suppressa*, Say, is furnished only with one or two lamelliform, elongated, oblique teeth.

Genus SESARA, Alb.

Is restricted to India, Burma, and Siam; some sixteen species are known, the majority of which are provided with teeth in the aperture. The simplest form in this respect is *S. helicifera*, Blanf., having only one long, curved, entering fold on the columella, while *S. harmeri*, Gude, is furnished with two raised, curved, short lamellæ on the base of the peristome. *S. tickelli*, Theob., and *S. hungerfordiana*, Theob., have a narrow aperture, with three teeth on the base of the peristome and one curved fold on the columella. *S. megalodon*, Blanf., also has a curved, entering fold on the columella, a small tooth on the outer lip, and a larger horizontal one on the basal margin, with a large, transverse plate between. *S. mouleyitensis*, Gude, is furnished with a large, curved, transverse plate near the basal margin, supported by two buttresses outwardly, and an entering, curved fold on the columella. In *S. pylaica*, Bens., no teeth are found, but the parietal callus has a raised lamella meeting a similar one on the basal margin, leaving only a narrow slit between.

We now come to an important group, i.e. the ENDODONTIDÆ, the first to be considered being the

Genus SCULPTARIA, Pfeiffer.

Only four species are known, with two or three varieties; they are small shells, characterized by their beautiful sculpture, and confined to Damaraland, South-West Africa. *S. sculpturata*, Gray, is provided with a long, entering, raised, flexuous fold on the parietal wall and two horizontal, raised lamellæ on the palatal wall, while *S. damarensis*, H. Ad., has a similar fold on the parietal wall and three raised, horizontal lamellæ on the palatal wall. *S. retisculpta*, Mts., the most beautifully sculptured form of all, has likewise a parietal fold, while the palatal wall is furnished with a strong, transverse ridge on the outer wall close to the peristome, raised into a tubercle on the base.

Genus ENDODONTA, Albers.

This important genus, with numerous species, distributed over Australasia and Polynesia, has been split up into several subgenera and sections. The first subgenus, DIGLYPTUS, Pils., has but one species: *E. pagodiformis*, Smith. It is furnished with a strong, entering, parietal lamina and two close columellar plicæ, terminating in a large callous nodule on the columellar lip. The subgenus STENOPYLIS, Fult., consists of three or four species of minute shells from the Philippine Islands, Australia, and New Guinea. One of these, *E. coarctata*, Mlldff., was originally placed in the genus

PLECTOPYLIS. It has the parietal callus raised into a flexuous, transverse lamella parallel with the outer and basal margins of the peristome, which are equally raised, nearly closing the aperture, while there are besides two internal parietal lamellæ.

The subgenus LIBERA, Garr., occurs only in the Society and Cook Islands. These shells are provided with revolving, entering folds on the parietal wall, and the lower part of the last whorl. *E. jacquinoti*, H. & J., from Tahiti, is a fairly large species, and possesses two revolving, entering lamellæ on the parietal wall, with one low curved fold on the columella and three raised, revolving lamellæ on the basal wall of the last whorl.

The subgenus ENDODONTA, s.s., ranges over the Sandwich, Society, and Pelew Islands. *E. lamellosa*, Fér., a Sandwich Islands species, is provided with no less than eight revolving, raised lamellæ: two on the parietal, one on the upper, four on the basal, and one on the columellar wall. *E. lacerata*, Semp., from the Pelew Archipelago, has only one entering lamella on the basal wall midway between the columellar angle and the periphery, one low revolving fold on the columella, while the parietal wall bears three raised ridges and several smaller ones between the latter and the columella, all these ridges being continued outside on the base of the shell as far as the peristome.

The subgenus THAUMATODON, Pilsbry, with numerous species, is distributed over Polynesia, New Zealand, New Caledonia, Tasmania, and the Philippines. *E. multilamellata*, Garr., a Cook Islands species, has three revolving lamellæ on the parietal wall, three on the basal wall, and one on the columella. *E. heptptychia*, Q. & M., from Guajam, an island in the Ladrones Archipelago, possesses two revolving, entering, parietal folds; three raised lamellæ on the outer wall, the middle one being largest; three on the basal wall, the middle one smallest; one on the columella; all these lamellæ are some distance from the peristome. *E. tomlini*, Gude, another form from Guajam, has, like the former, two parietal folds; three raised lamellæ on the outer wall, the topmost being smallest, and one the basal wall.

The subgenus NESOPHILA, Pilsbry, is of Polynesian distribution; *E. tiara*, Migh., from the Sandwich Islands, is the largest of all the Endodonts, a full-grown specimen in my possession measuring as much as 14 mm. in diameter; it has a wide aperture, and is provided with eight or nine low, revolving, entering folds on the parietal wall but without any palatal teeth or lamellæ. *E. hystrix*, Migh., and *E. jugosa*, Migh., also from the Sandwich Islands, are provided only with one low, revolving, entering fold on the parietal wall.

The subgenus PTRYCHODON, Ancey, is a small group of minute species confined to New Zealand. *E. hectori*, Sut., has five parietal lamellæ, the principal one, stout and median in position, being grooved or bifid, the other four smaller and placed between it and

the columella, which bears two, well-developed lamellæ, the inner one with two or three sharp points ; the second high, shaped like a sharp tooth ; in addition, there are seven rather stout elevated lamellæ on the palatal wall, evenly distributed. *E. pseudoleioda*, Sut., is furnished with three folds on the parietal wall, one columellar and eight palatal plicæ, while *E. wairarapa*, Sut., with five parietal and one columellar lamellæ, has no less than ten palatal plicæ.

The subgenus HELENOCONCHA, Pilsbry, also a small group, is only found in St. Helena. *E. polyodon*, Sowerby, has three, revolving, entering liræ on the parietal wall, the upper and lower frequently double ; there are about seven palatal plicæ, which are rather evenly distributed and extend some distance within. *E. minutissima*, Smith, has as many as six parietal liræ and from eight to ten palatal plicæ. The last Endodont subgenus to be considered is AFRODONTA, M. & P., with some six known species found in South Africa. *E. trilamellaris*, M. & P., possesses three, short, low folds, one parietal, one palatal, and one basal.

The Pyramiduloid subgenus HELICODISCUS, Morse, is restricted to North America, and contains four or five known species. *P. parallela*, Say, has radial series of two or three horizontal palatal teeth, these series being about one-third of a whorl distant from each other. It is probable that the earlier series are absorbed by the animal as the growth of the shell proceeds. In *P. fimbriata*, Weth., the series consist of a vertical, stout lamella on the outer wall and a smaller oblique one on the basal wall.

Genus RUTHVENIA, Gude,

was originally established as a section of *Plectopylis* until Lieut.-Col. Godwin-Austen investigated the anatomy and concluded that it was allied to *Thysanota*. Five species are known, four of these occurring in Ceylon and one in Southern India. They are small, fragile shells, bearing two series of small, horizontal, callous denticles on the palatal wall and a solid, transverse plate on the parietal wall. In some forms additional transverse denticles are found on the palatal wall.

The important and large group of HELICIDÆ next demands consideration, the first genus to be reviewed being

Genus ASHMUNELLA, Cock. & Pils.

This genus, of about thirty species, is restricted to the United States. *A. thomsoniana*, Anc., is provided with one oblique, parietal denticle, one transverse plate on the outer margin of the peristome, and two denticles on the lower margin. *A. levettei*, Bld., has a short oblique, parietal fold, one transverse fold on the outer margin of the peristome, and two short, horizontal plicæ on the lower margin.

Genus POLYGYRA, Say.

A large genus divided into three sections, all confined to North America. The first section, POLYGYRA, s.s., has about fifty species. *P. cereolus*, Muhlf., and *P. septemvolva*, Say, are characterized by a raised parietal callus, with an oblique, entering fold and a scrobiculation behind the peristome. *P. espiloca*, Bld., and *P. auriformis*, Bld., have in addition a transverse fold on the outer lip and a horizontal one on the lower lip of the peristome. *P. uvulifera*, Shutt., and *P. auriculata*, Say, have a similar armature, but more produced, the raised parietal plate is more tortuous and tongue-shaped and projects between the plates on the peristome almost closing the aperture. *P. hippocrepis*, Pfr., possesses an extraordinary form of armature, having the raised parietal callus provided with two parallel, horizontal entering laminæ united at their inner termination by a high raised, curved, transverse fold, in the shape of a horse-shoe, which coincides with a hollow, raised, transverse tubercle on the base of the outer wall near the scrobiculation behind the peristome.

The section TRIODOPSIS, Raf., also contains about fifty species, with numerous varieties. Here the armature is less complicated, and in some forms altogether absent, but the peristome in all is strongly developed. *P. tridentata*, Say, and *P. fraudulentata*, Pils., have one oblique, entering fold on the parietal callus and two denticles on the peristome, one above and one below, while *P. profunda*, Say, is provided merely with a denticle on the basal margin of the peristome. *P. Sayi*, Binn., and *P. elevata*, Say, have an oblique entering denticle or fold on the parietal callus, whereas *P. albolabris*, Say, *P. multilineata*, Say, and *P. clausa*, Say, are devoid of any teeth, folds, or lamellæ whatever.

The section STENOTREMA, Raf., numbers some twenty-two species, the majority having the aperture nearly closed by the raised, transverse lamella on the parietal wall. In *P. spinosa*, Lea, this lamella has the distal end curved inwardly, fitting into the upper angle formed by the upper and outer margins of the peristome, which is considerably thickened; in addition an internal short buttress unites a part of the parietal and basal walls with the columellar wall, one-quarter of a whorl behind the peristome, this buttress being distinctly visible through the shell-wall, but can be more easily observed on breaking away a portion of the lower shell-wall, immediately behind the peristome. *P. labrosa*, Bld., and *P. stenotrema*, Fér., have the aperture still more obstructed. In these two species the basal margin of the peristome is inwardly produced with a small sinus near the distal end, and the outer margin carries a short tubercle, forming a sinus with the basal margin, into which the distal end of the parietal plate fits. *P. monodon*, Rack., and *P. fraterna*, Say, have a less complicated armature, being furnished simply with the raised, transverse lamella on the parietal plate, no processes occurring on the peristome.

Genus POLYGYRELLA, Binney.

Only three species are known, all American. *P. polygyrella*, Bld., has the mouth of the shell obstructed only by a raised, transverse lamella on the parietal callus, giving off a short horizontal fold. On the base, one-half of a whorl from the aperture, there may be seen through the shell-wall three short, horizontal, white lamellæ and one-quarter of a whorl further back the remains of a former set, partly absorbed.

Genus POLYGYRATIA, Gray.

This genus is split up into four sections ; the first, POLYGYRATIA, s.s., with two species, one found in Brazil, the other in Bolivia. The first, *P. polygyratia*, Born, is a large, disc-shaped shell, a specimen in my collection measuring as much as 47 mm. in diameter. It is provided internally with short, horizontal and oblique folds, which can only be observed by breaking away parts of the shell-wall, which is very thick and solid. In the specimen examined three short, horizontal lamellæ occur on the outer wall, one-third of a whorl behind the mouth ; one-third of a whorl further back is found a similar group, and in addition, facing the latter, an oblique, sinuous, raised fold on the parietal wall, with a short, low, horizontal lamella immediately below. The first to draw attention to these structures was Moricand,¹ who states that having examined several specimens he found these lamellæ to vary in number from one to three on either side, three series usually occurring in the last whorl.

Of the subgenus RIDLEYA, Ancey, only one species is known, *P. quinquelirata*, Smith, from the island of Fernando Noronha, a small shell, measuring only 5 mm. in diameter. It has a small aperture, which is provided with two entering, horizontal folds on the parietal wall, reaching near to the aperture, two on the basal, and one on the outer wall not reaching as far as the parietal, the lower of the latter intercalating between the outer and basal folds.

The section SYSTROPHIA, Pfr., contains some twenty-two species, all South American, and all many-whorled forms. *P. ortonii*, Crosse, from Ecuador, is simply deeply scrobiculate at the upper part of the peristome, the corresponding tubercle causing the aperture to assume a triangular shape. In *P. entodonta*, Pfr., however, are found three short, horizontal lamellæ on the outer and basal walls, some distance behind the peristome.

Genus MOELLENDORFFIA, Ancey.

This was at first classed as a subgenus under *Helicodonta* by Dr. Pilsbry, but subsequently he modified his views as to its affinities and considered it to be closely related to *Chloritis*. On conchological as well as geographical grounds this appears to me a more reasonable

¹ Mém. Soc. Phys. Hist. Nat. Genève, vol. xi, 1846, p. 151, pl. v, figs. 1-3.

attitude, and will probably be confirmed when the anatomy comes to be examined. The genus is distributed over China, Tonkin, Cambodia, and Formosa, with an outlying species in the Loo-Choo Islands. It is characterized by the absence of internal barriers on the parietal wall. In the subgenus MOELLENDORFFIA, s.s., comprising ten species, the outer edge of the parietal callus is solute, erect, and sinuous, bearing a short, raised tooth at the sinus; generally there are besides two furrows or sulci on the outer and basal wall, with corresponding lamellæ internally. In the subgenus MOELLENDORFFIELLA, Pilsbry, with only one species known—*M. erdmanni*, S. & B., from China, a flattened shell with sunken spire—the parietal callus is without the raised, sinuous edge, and the margins of the peristome are approximating. The subgenus TRIHELIX, Ancey, on the other hand, has the edge of the parietal callus slightly raised, but it is not sinuous and devoid of the raised tooth characterizing the first subgenus. *M. horrida*, Pfr., a Tonkin species, has two short sulci at the upper part of the last whorl—one behind the peristome, the other a short distance back, their upper ends convergent—and a similar one on the base, also behind the peristome, these three sulci having corresponding short lamellæ inside and forming a triangle. *M. hiraseana*, Pilsbry, from Formosa, has a long, curved scrobiculation at the upper part of the last whorl, a short distance behind the peristome, and a shorter, oblique one on the base, nearer the peristome, both with corresponding lamellæ inside. *M. eucharistus*, Pilsbry, a Loo-Choo species, is simply furnished with a very short sulcus on the base of the last whorl, close to the peristome, the corresponding short lamella inside being only slightly raised.

Genus STEGODERA, Martins,

and its subgenus TRAUMATOPHORA, Ancey, were for many years classed as subgenera under *Plectopylis*, until in 1905 Dr. Pilsbry suggested their relationship to *Moellendorffia*. Each contains only one species from China. The former is represented by a sinistral species—*S. angusticollis*, Mts.—which is devoid of internal barriers, but the last whorl is strongly constricted a short distance from the aperture, leaving only a narrow slit for the animal to emerge. The latter is represented by a dextral form—*S. triscalpta*, Mts.—which is also constricted a short distance from the aperture, but only slightly so. It is, on the other hand, furnished at the same place with three strongly developed sulci, the two uppermost long, curved, ascending at first, then slightly descending and terminating close to the peristome; the one at the base shorter, oblique; all three have corresponding elevated lamellæ inside the mouth, closely approaching the inner wall.

Genus CORILLA, Adams.

In the present genus and the next—PLECTOPYLIS—the internal armatures reach an extraordinary development. A careful

examination of immature specimens has revealed the fact that a new set of palatal lamellæ is formed on completion of each half of a whorl, after which the previous set is absorbed by the animal. I have observed several shells which contained two sets of barriers at a distance of half a whorl; in some cases the older set had almost vanished, only the foundations of the lamellæ being visible from the outside through the shell-wall. I have already in the introductory remarks to this address alluded to the fact that whereas in one species—*C. adamsi*, Gude—the mature shells are devoid of armature, the immature ones are provided with five oblique, palatal lamellæ, the same as obtains in the other members of the genus. Ten species are known, all with one exception—*C. anax*, Bens., which occurs in southern India—being natives of Ceylon.

In two species—*C. beddomeæ*, Hanl., and *C. anax*, Bens.—there are two or three horizontal, curved, parietal, entering folds, while in the other seven Ceylon species the number of parietal folds varies from one to three. One of these—*C. humberti*, Brot—possesses only one short, palatal lamella on the basal wall near the suture, corresponding to the fourth in the other species. The parietal folds are not formed until the shell approaches completion, while the palatal lamellæ in the immature shells are invariably much larger than in mature specimens, being almost triangular, overlapping, and reaching nearly to the parietal wall.

Genus PLECTOPYLIS, Benson.

This genus is divided into five sections and comprises some ninety species, ranging from North-East India through Burma, Tonkin, South and Central China, with one outlying species in the Loo-Choo Archipelago. They all have the interior of the last whorl obstructed by a transverse plate or plates on the parietal wall, and several transverse, oblique, or longitudinal denticles or plates on the palatal wall. In some forms—for instance, *P. woodthorpei*, Gude, a member of the section PLECTOPYLIS, s.s.—the palatal armature is in two series, the anterior set consisting of three thin, horizontal folds, while the posterior series is much more complicated, showing a thin, long, horizontal fold near the suture, a second one below it, still longer, and with an elevated compressed denticle posteriorly, next a very short, curved fold, below this a strong, vertical lamina, indented at the middle and giving off posteriorly at its lower extremity an obliquely descending ridge, where also occurs a small denticle, and on the upper extremity a similar ridge or support; another long, thin, horizontal fold is found near the lower suture. The parietal barriers consist of two, nearly parallel, vertical laminæ, the anterior one the shorter and giving off at each extremity anteriorly a horizontal fold, the lower one short, the upper one revolving parallel with the suture and joining the ridge at the aperture; below this occurs a free thin horizontal fold, parallel with the lower suture and joining the ridge on the parietal callus.

In *P. macromphalus*, Blanf., belonging to the section ENDOTHYRA, the anterior set of the palatal barriers is much simpler, being composed of four short, broad, flattened, straight, horizontal folds, while the posterior set consists of six narrow, horizontal lamellæ, the fourth and fifth being a little obliquely deflected posteriorly. The parietal barriers again are much simpler than in *P. woodthorpei*, consisting of a strong, vertical plate provided posteriorly at its lower extremity with a minute denticle.

P. laomontana, Pfr., from Laos, a member of the section *Chersæcia*, is provided on the parietal wall with a single strong, lunate lamella, its convex side facing the aperture and deflexed posteriorly below (Fig. 1, *b*). On the palatal wall are found seven more or less horizontal lamellæ; the second (from above) bifurcated posteriorly, the sixth (which is very short) and the seventh (a little longer) have each an elongated denticle posteriorly (Fig. 1, *c*).

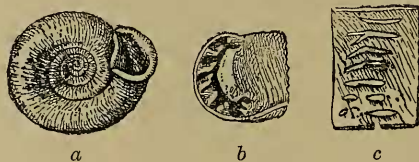


FIG. 1.—*Plectopylis laomontana*.

P. brachyplecta, Bens., a member of the section ENDOPLOON, found in Burma, has the palatal barriers in one series, the upper fold being thin and horizontal; next come four short oblique folds, nearly parallel, concave towards the aperture, and below these a short, thin, horizontal fold near the lower suture; the second fold has a short, straight fold united to it posteriorly, while posteriorly between the fifth and sixth folds occurs another short oblique lamella. The parietal armature, on the other hand, consists of two strong, vertical laminæ, with short supports or ridges at the upper and lower extremities; a short, free, horizontal fold occurs below the vertical plates. In another species of the section ENDOPLOON, *P. françoisi*, H. Fisch., occurring in Tonkin (see Fig. 2), the palatal folds are also six in number, the two upper and the basal one being horizontal, rather long, while the third, fourth, and fifth are short, semicircular, oblique, and a callous, transverse ridge connects the second, third, fourth, and fifth. The parietal armature is composed of two strong, obliquely divergent, transverse plates, with a short horizontal fold above and a longer one below.

In the section *CHERSÆCIA*—a typical example being *P. shanensis*, Stol.—the palatal barriers are again in two series, the anterior set comprising six thin, horizontal, subequal folds, while the posterior series is composed of nine short denticles arranged in a vertical row. The parietal armature consists of a strong, horizontal, median fold, revolving over nearly half of the last whorl, and united to the

parietal ridge at the aperture but free posteriorly ; a short distance beyond it occurs a strong, vertical lamina with, posteriorly, a short support below, and anteriorly a strong, horizontal fold, extending a little over half the length of the median fold, while a third horizontal, thin fold, close to the lower suture, commences just below the vertical plate and is united with the parietal ridge at the aperture. Another species in the same section, *P. brahma*, G.-A., has the palatal barriers also in two series, but here the anterior set is composed of but four rather short, horizontal folds, two above and two below, with a considerable space separating the upper and lower folds ; while

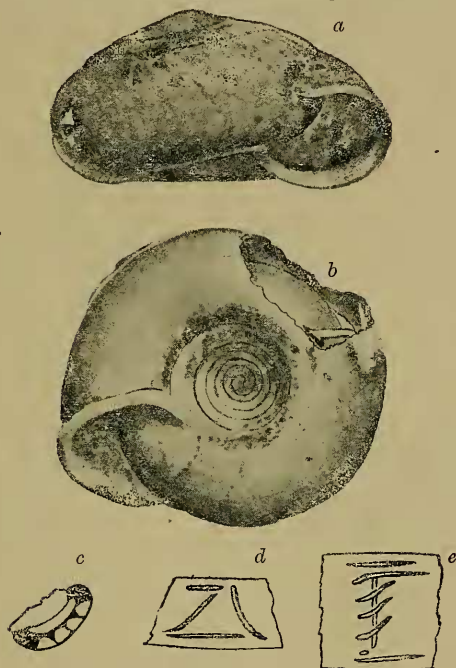


FIG. 2.—*Plectopylis francoisi*.

the posterior series exhibits no less than fourteen minute denticles arranged in a transverse row slightly deflected anteriorly below. *P. cyclaspis*, Bens., differs considerably in its armature from the other members of the genus, the parietal barrier being trifurcate with a free, short, horizontal fold below, while the palatal barriers are five in number : the two upper short and horizontal, the third crescent-shaped with the extremities curved downwards, the fourth strong, broad, and vertical, intercalating with the two lower arms of the parietal lamina, and below this another short horizontal fold.

The section SINICOLA contains nineteen species, one being found in

Tonkin—*P. emigrans*, Mlldff. ; one in the Abor Hills, Assam—*P. babbagei*, Gude ; one in the Loo-Choo Islands—*P. hirasei*, Pils. ; all the others being natives of China. The armature is generally less complicated than in the other members of the group ; in *P. schistoptychia*, Mlldff., for instance, the parietal barrier consists simply of strong vertical lamina, with a short support posteriorly at its lower extremity and two similar supports anteriorly, one above and one below ; while the palatal armature consists of eight small denticles in two series of four each, a thin, horizontal fold above these near the suture, with a minute denticle near its posterior termination (see Fig. 3). In *P. diptychia*, Mlldff., on the other hand, the parietal

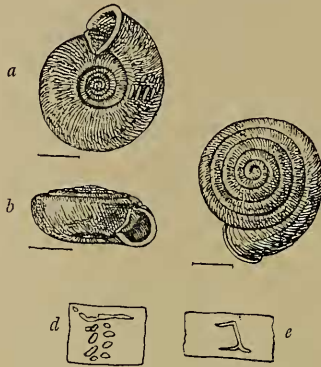


FIG. 3.—*Plectopylis schistoptychia*.

armature is composed of two strong vertical laminae, almost parallel but slightly convergent above, the anterior one with a short support anteriorly above, the posterior one crescent-shaped ; there are six short more or less horizontal palatal folds (see Fig. 4).

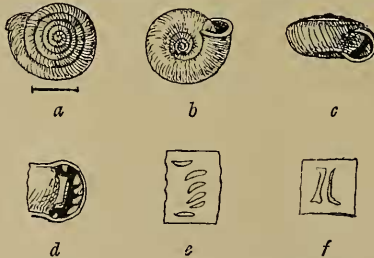


FIG. 4.—*Plectopylis diptychia*.

P. multispira, Mlldff., possesses one strong, lunate, transverse parietal plate, on the anterior side of which are found a short, horizontal fold above, next five minute denticles—the second and third being united, forming a double one (see Fig. 5). The palatal folds are

six in number, more or less horizontal, with a little elongated denticle posteriorly between the fifth and sixth.

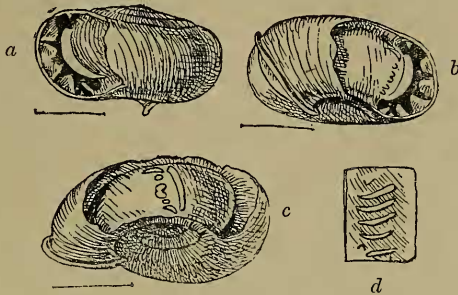


FIG. 5.—*Plectopylis multispira*.

Genus SAGDA, Beck.

This is restricted to Jamaica, except the subgenus ODONTOSAGDA, Mts., which occurs in Haiti and Cuba. The armature, generally visible through the shell-wall, is in the form of revolving, internal laminae or interrupted laminae forming series of denticles; in the section of HYALOSAGDA, Mts., they are, however, absent. *S. cookiana*, Gm., exhibits this interrupted lamina on the basal wall, and has, in addition, a short columellar fold.

In *S. alveare*, Pfr., the basal lamina is strongly developed and continues over the whole of the last whorl; the columellar fold is also well developed in some specimens. In *S. spiculosa*, Shutt., the basal lamina is very long, extending beyond the last whorl, but in *S. triptycha*, Shutt., it is only about one-third of a whorl long, although the foundation of the previous lamina can be observed through the shell-wall for a considerable length; the columellar fold is here in the form of a strong transverse nodule.

Genus PLEURODONTA, Fischer de Waldheim.

A large genus divided into several subgenera, or sections, distributed over the West Indies and northern South America. Many species are provided with teeth at the aperture. The Jamaican *P. bainbridgei*, Pfr., and *P. acuta*, Lam., with its numerous varieties, exhibit one or two teeth on the basal margin of the peristome, becoming more strongly developed and entering in *P. lucerna*, Müll. In *P. soror*, Fér., and *P. peracutissima*, C. B. Ad., also from Jamaica, the mouth is much contracted, and the basal margin bears four strong, elevated, entering teeth nearly closing the aperture; behind the basal margin of the peristome occur corresponding scrobiculations. Most of the other forms of the section PLEURODONTA, s.s., which is restricted to Jamaica, possess variants of his form of armature.

The section CAPRINUS, Montfort, distributed over the Lesser Antilles, possesses some remarkable forms. *P. nuxdenticulata*,

Chemn., from Martinique, has a strongly developed peristome, bearing two or more teeth or denticles on the basal and two on the outer margin, with a very strong, raised lamina on the parietal callus, the aperture being still further reduced by constriction behind the peristome. *P. nigrescens*, Wood, an inhabitant of the island of Dominique, bears a strong, obliquely entering lamella on the parietal wall, a short, strong fold on the columellar margin, and a longer, entering lamella on the basal margin of the peristome, with a corresponding scrobiculation.

P. auridens, Rang, the only species of the section GONOSTOMOPSIS, Pilsbry, from Martinique, and its variety *oligotricha*, Anc., is only provided with a short, raised lamella on the outer margin of the peristome. The section CARACOLUS, Montf., occurring in Cuba, Haiti, and Porto Rico, is composed of large species with ample aperture devoid of teeth or lamellæ.

The section ISOMERIA, Alb., confined to Ecuador, Colombia, and Peru, has most of its species furnished with one or more small denticles on the peristome, while a short parietal fold is also found in some species. *P. subcastanea*, Pfr., is an exception, having a strong, entering lamella on the outer part of the basal margin with a corresponding deep scrobiculation.

The section AMBAGES, Gude, consists of only two species from New Grenada, *P. vexans*, Dohrn, and *P. ænigma*, Dohrn, the latter twice the size of the former, but both having the armature on the same plan. The aperture is ear-shaped and considerably narrowed by its lamellæ; the basal margin is sinuous, strongly callous, and reflected, bent upward in the middle, forming an obtuse, squarish process; the upper and outer margins broadly expanded, arcuate, and bearing a short, entering fold in a line with the peripheral angulation, and below this a strong, raised, entering lamella, with a corresponding deep scrobiculation behind the peristome; the parietal callus has the margin sinuous, raised, continuous with the peristome, and gives off about the middle a very strong, raised, flexuous, obliquely entering lamella.

The section LABYRINTHUS, Beck, stands out from the other members of the group on account of the considerable constriction of the aperture in many of the species. It is characteristic of northern South America, extending northward in Central America as far as Costa Rica. They are all more or less flattened shells with narrow aperture. *P. labyrinthus*, Chemn., from Panama, has a strongly raised parietal callus continuous with the peristome and giving off a strong, median, sinuous, obliquely entering lamina, which almost meets a strong, high, triangular, entering lamina on the outer end of the basal lip, which bears a second, smaller lamina nearer the columella, with a deep sinus between them and corresponding deep pits or scrobiculations behind the peristome. *P. bogotensis*, Pfr., has the parietal callus and lamina similar to those found in *P. ænigma* and *vexans*,

but the upper lip here has a strong nodule, the basal lip bears on its outer portion two strong, entering lamellæ on a common base, and nearer the columella a strong, entering lamella and two denticles, all on a common base, a deep sinus occurring between these two sets, and all having corresponding scrobiculations. *P. clappi*, Pils., from Columbia, has the peristome developed to an unusual degree; its parietal callus and lamina resemble those in the last-mentioned species, but there is only one lamella on the outer part of the basal lip, and nearer the columellar there are two parallel, entering lamellæ, while the upper lip also has an entering lamella; all these folds or lamellæ are unusually well-developed and strong, especially those near the columella.

The next section, THELIDOMUS, Swainson, is not remarkable for its teeth or lamellæ, these being, generally speaking, conspicuous by their absence, but the section POLYDONTES, Montf.—consisting of but three species confined to Cuba—has one very remarkable member, *P. imperator*, Montf., which has an unusually strong and thick peristome, its inner edge being provided with a series of very strong teeth over its entire length and an obtuse fold near the columella.

Genus AULACOSPIRA, von Moellendorff.

Some seven species, all minute, are known, occurring in the Philippine Islands. Most of the species have four or five teeth in the aperture, one being provided with only one, *A. hololoma*, Mlldff., and one being edentulous, *A. mucronata*, Mlldff. *A. azpeitia*, Hid., has a long oblique pliciform tooth on the parietal wall, one transverse on the columella, and three smaller ones on the basal and outer margins.

Genus METODONTA, Mlldff.

A small genus comprising four known species from northern China, with lunate aperture nearly closed by two large teeth situate on a transverse callous ridge on the basal and outer walls a short distance from the edge of the peristome, and meeting two somewhat small teeth on the parietal callus, also on a common base, and with a small denticle on the columella. Examples: *M. houaiensis*, Cr., and *M. moltneri*, Greidl.

Genus HELICODONTA, Férussac.

This group of European, north African, and south-east Asiatic distribution is characterized by a discoid form, or nearly so, of shell, the aperture being mostly triangular, lunar, rhomboid, with frequently teeth on the margins of the peristome. The section LOOSIA, Hesse, was established for the reception of one species, *H. diodontia*, Fér., from Hungary, a small flattened shell, with sub-triangular aperture, the upper margin being furnished with a short, strong, obtuse tooth, while the lower margin carries a very stout, broad fold, which is continued within for about one-third of a whorl

by a slender low revolving lamella. The section ASPASITA, West., comprises three species, from Hungary. *H. triaria*, Friv., has two small denticles, one on the upper and one on the lower lip, while *H. trinodis*, Kim., has these two denticles stronger and more developed, and bears in addition a strong, entering, oblique fold on the parietal wall. The section TRISSEXODON, Pils., contains only two species, one from the Pyrenees and one from Southern Spain, *H. constricta*, Boub., and *H. quadrasi*, Hid. Here the parietal callus has the outer edge raised into a transverse lamella, narrowly constricting the aperture. The section MASTIGOPHALLUS, Hesse, again was established for the reception of one species, *H. rangeana*, Fér., also from the Pyrenees. This is a remarkable shell, having the upper margin fluted at its junction with the peripheral carina. The aperture is very narrow, the outer margin is constricted and bears a short, oblique fold, while the lower margin has a raised callus. In the section CARACOLLINA, Beck, we find *H. tlemcenensis*, Bgt., from Algeria, a species also with a narrow, lunar aperture, furnished with a short denticle on the basal wall and a broader one on the outer margin.

The next group to claim our consideration is that known as the PUPILLIDÆ, most of the members of which are furnished with teeth or lamellæ at the mouth. The first to be dealt with is the

Genus ANOSTOMA, Fischer.

The species are few in number and restricted to northern South America. They are peculiar from the fact that the last whorl is carried upwards, the mouth being consequently on a level with the periphery the effect being that the animal carries its shell with the spire downwards. *A. globulosum*, Lam., and *A. verreauxianum*, Hupé, are typical examples, the former having two strong, raised, flexuous, entering laminæ on the parietal wall and four raised, flexuous entering folds on the outer wall; the latter has only three short lamellæ on the outer wall, the upper one being very small, the two parietal laminæ are also less developed than in its congener.

Genus HYPSELOSTOMA, Benson,

ranges over Burma, Farther India, China, Malaysia, the Philippine and Loo-Choo Islands. They are all very small shells. In the type of the genus *H. tubiferum*, Bens., the last whorl, as in the genus *Anostoma*, is carried upwards, the mouth being horizontal and on a level with the apex. In the other species the last whorl is solute and not carried upwards, the mouth being either oblique or vertical. The aperture exhibits from four to seven lamellæ; in *H. tubiferum* one of the two parietal ones sometimes being bidentate, with one columellar and four palatal ones.

Genus TONKINIA, Mabille,

is allied to *Hypselostoma*, and is known by a single species—*T. mirabilis*, Mab., from Tonkin. The aperture is on a level with the spire, as in the genus *Anostoma*, the animal thus carrying the shell, which measures only 5 mm. in diameter and 2 mm. in height, with the spire downwards. The narrow, elongated mouth is furnished with a strong, entering, parietal lamella and a columellar fold, also entering, and bifid at the inner extremity, the latter forming a little channel at the angle of the columellar margin of the peristome.

Genus BOYSIDIA, Ancey,

occurs in India, Farther India, Malaysia, and China. In *B. plicidens*, Bens., there are three parietal lamellæ, the two upper ones being deeply entering, the second triangular and more elevated anteriorly, the third small and deep-seated. The palatal denticles are usually five in number, deep-seated, the three upper largest, the two lower minute; an elongated denticle occurs on the columella. *B. messengeri*, Bav. & Dautz., and *B. gereti*, B. & D., from Tonkin, possess one parietal and one columellar, entering lamellæ, but whereas the former has three the latter has only one palatal fold; on the other hand, *B. robusta*, B. & D., and *B. paviei*, B. & D., also from Tonkin, are provided each with one columellar and two parietal laminæ, but the former possesses three palatal and the latter four palatal plicæ; finally *B. lamothei*, B. & D., is furnished with three parietal, one columellar, and five palatal folds, the upper parietal forming a sinus with the upper palatal fold.

Genus BIFIDARIA, Sterki.

Originally established as a subgenus of *Pupa* [i.e. *Pupilla*], it has since been raised to generic rank by Dr. Pilsbry, the species ranging over America, Asia, Polynesia, New Caledonia, and Mauritius. *B. tuba*, Pils., a native of Arizona, has the angular and parietal lamellæ combined into one long fold; there are: a deep-seated columellar lamella—slightly bifid—small, short, upper and lower palatal and basal folds, with a minute denticle between them, and another at the base. *B. huttoniana*, Bens., an Indian form, possesses a sinuate, parietal lamina, sometimes bifid, two palatal folds, and one or two columellar plicæ.

Genus ODONTOSTOMUS, Beck,

has several species in South America, fairly large, with elongated, much obstructed, aperture. *O. pantagrulinus*, Moric., from Brazil, has one oblique, entering, high, tongue-shaped lamella on the parietal callus with buttresses on the columellar side; the columellar lamina is erect, long, plate-like; there is a basal fold varying from simple and acute to compound and serrate; and finally it possesses

two palatal folds, the lower compressed, the upper large, elongate, and usually serrate; a few supra-palatal denticles generally occur above these. The subgenus *SPIXIA*, Pils. & Van., contains about thirty species, ranging from the Argentine to Brazil. The shells are less strong but more turreted, and usually have five folds in the aperture—one compressed parietal lamina, one oblique columellar, one basal, one compressed palatal, and one small supra-palatal fold; the basal and supra-palatal folds are sometimes obsolete or absent. The subgenus *PLAGIODONTES*, Doering, with about seven Argentine species, is somewhat peculiar in having a composite parietal barrier, formed by the fusion of three laminæ, i.e. the angular, parietal, and infra-parietal, it is outwardly trifold; there are besides two palatal folds—the upper twisted, two supra-palatal, a small compressed basal, and a columellar fold, the latter being largest of all. With the exception of *V. patagonicus*, all the species of this subgenus have in addition a high transverse lamella behind the lower palatal fold.

Genus *TOMIGERUS*, Spix.

Contains some seven known species occurring in South America, and is divided into two subgenera: *TOMIGERUS*, s.s., with one species, *T. gibberulus*, having two lamellæ on the outer lip, and *PILSBRYELLA*, Ihr., comprising the remainder, with only one lamella on the outer lip. A typical example is *T. clausus*, Spix, which exhibits two oblique, entering, parietal lamellæ, with a small denticle between; three entering, compressed lamellæ on the baso-columellar margin, the middle one the strongest, and a high, flexuous, oblique lamina on the outer lip, bidentate near the upper extremity; a corresponding scrobiculation is found behind the lip. A minute shell, 1.5 mm. \times 1.5 mm., from St. Helena, *perexilis*, Smith, has been doubtfully referred to this genus; in this the upper edge of the peristome is notched, having the appearance of being the termination of a tube.

Genus *STROBILOPS*, Pilsbry.

This genus has a peculiar distribution, being found in North America—one species also occurring in Jamaica—extending through Mexico and Central America to Venezuela. The mainland of China produces one, the island of Korea another, and a species has also been discovered in Japan, while the Philippine Islands contribute two. These two last were originally described as forms of *Plectopylis* by von Moellendorff, but Dr. Pilsbry has referred them to the present genus. *S. quadrasi*, Mlldf., from Luzon, is, like all the members of the genus, a minute species, measuring only 3.5 mm. in diameter. It bears two parallel, horizontal folds on the parietal wall (see Fig. 6c and e), extending over nearly half the whorl, the upper one the stronger and united to the ridge at the aperture, the lower one thinner and not reaching quite so far; at their

posterior terminations they are united by a slight, vertical ridge, which projects a little beyond the upper fold. The palatal wall bears three short, parallel, horizontal folds at one-third of the whorl from the aperture.

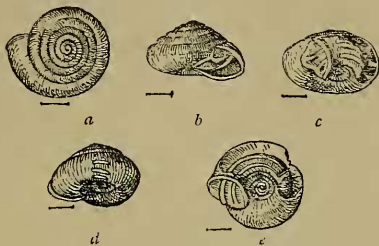


FIG. 6.—*Strobilops quadrasi*.

Strobilops trochospira, Mlldff., which occurs in the island of Cebu, is a trifle larger than the last-named species, measuring 4 mm. in diameter; on the parietal wall are found two long, parallel, horizontal folds revolving over nearly half a whorl, the upper one being the stronger and united to the parietal ridge at the aperture, while the lower one is thinner and terminates at a short distance from the parietal ridge; a very thin, short, horizontal fold occurs

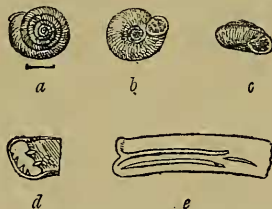


FIG. 7.—*Strobilops trochospira*.

posteriorly between these two (see Fig. 7e). There are five short, thin, horizontal, palatal lamellæ, descending a little anteriorly (see Fig. 7d).

Genus PUPILLA, Turton (*sensu lato*).

This is widely distributed, occurring in Europe, Asia, Africa, and America. It possesses numerous minute species, which are provided with teeth or folds in the aperture. *P. muscorum*, Lin., of circumpolar distribution and a well-known shell in these islands, only possesses a small denticle on the parietal callus. *P. brevicostis*, Bens., an Indian species, is provided with five or six plicæ: one short angular, one oblique, entering parietal, one columellar, and two or three palatal, rather deep-seated.

P. pentodon, Say, from North America, has from six to nine denticles or folds, those on the peristome being situate on a ridge of white callus; there may be one or two on the parietal wall, one

or two on the columella, and from three to five on the palatal margin, some of these being strongly developed.

Genus VERTIGO, Muller (*sensu lato*),

also a genus of numerous minute forms, is of world-wide distribution. Many of the species have the mouth very much obstructed by folds and teeth, although in a certain number, such as *V. edentula*, Drap., and *V. minutissima*, Hartm., two British species, these barriers are absent. *V. ovata*, Say, a North American species, has generally six lamellæ: two parietal, two columellar, and two palatal.

It only remains for us to consider the

Genus CLAUSILIA, Draparnaud.

A large genus of wide distribution, being found in Europe, Asia, Northern Africa, South America, and Porto Rico. A great number of sections or subgenera have been established, some of doubtful value. The aperture is comparatively small, usually pear-shaped, provided with two spiral, entering lamellæ—usually on the parietal wall, the lower sometimes on the outer lip—continued internally as far as the seat of attachment of the pedicle of the clausilium; the upper follows the spiral convolution of the columella, and becomes the columellar fold, a second fold further back is known as the sub-columellar fold; these two folds form a long, flexuous groove, slightly dilated towards the aperture, but contracted further down. A curved, flexuous, tongue-shaped, elastic plate, known as the clausilium, characterizes and gives its name to the genus; higher up it becomes contracted into a narrow, twisted pedicle, its distal extremity attached to the inner shell-wall, between the distal extremities of the columellar and sub-columellar folds, the groove between these, lower down, receiving the clausilium as it is pushed to one side by the animal's extrusion. In addition there are a number of palatal plicæ behind the aperture and usually showing through the shell-wall. In some species two of these plicæ have the posterior extremities curved and approximating, ultimately uniting and forming the so-called lunella. While the animal is retracted within its shell the elastic pedicle causes the clausilium to rest against the sub-columellar fold on the inner side and against the shorter palatal plicæ or the lunella, when present, on the outer side, the anterior angle of its inner margin slightly projecting inwardly over the sub-columellar fold, an arrangement which effectively prevents the clausilium being forced to one side from without, thus securing the animal against intruding enemies. During extrusion of the animal the clausilium is pushed sideways into the groove between the columellar and sub-columellar folds, only its anterior portion being pressed slightly forward at the dilated part of the groove. The clausilium may, therefore, be regarded to act as a sliding door,

and while closed during retraction of the animal the spaces between the palatal plicæ are sufficient to admit air for breathing purposes. This peculiar sliding action of the clausilium I have not seen referred to by any previous author,¹ which may possibly be explained by the fact that the species which have served as a basis of investigation are rather small, and their examination is consequently somewhat difficult. This difficulty may be overcome by utilizing some of the larger Japanese forms—such as *C. martensi*, Herkl., and *C. valida*, Pfr. Five species belonging to the Palæarctic subgenus ALOPIA are without clausilium.

This completes our survey of the various groups of land mollusca furnished with armature.

NOTE ON *XYLOPHAGA PRÆSTANS*, SMITH.

By J. R. LE B. TOMLIN, M.A., F.E.S.

Read 12th March, 1920.

THIS species was described in these "Proceedings" (vol. v, p. 328). I am now able to give more definite details as to its habitat, and the following notes are written by Capt. J. H. Walker, the master of a trawler, who was the original discoverer, in a letter received 28th October, 1919:—

"I have taken this shell off the Durham and Northumberland coast in various depths of water from 25 to 45 fathoms on five or six occasions, and always on pitchpine logs or masts that had been a long time in the water. I used to split the wood with wedges and take the shell out alive and keep it alive in water for several days.

"I noticed the animal was white with a fairly long siphon. I kept them in a 2 lb. glass jam-jar filled with water, and the animals could reach the surface of the water (about 4 inches), except the very smallest.

"I found they always bored across the grain of the wood in a perpendicular direction, and the larger the shell the deeper the cavity.

"On the top surface of the log or mast there was nothing to indicate the presence of shells except a number of very small holes like pin-holes.

"My largest specimens are fully $1\frac{1}{8}$ inches in diameter, whilst my largest *X. dorsalis* is only $\frac{3}{4}$ in. in diameter. I always found *X. dorsalis* in hard wood, oak, elm, or teak.

"Some of the largest specimens of *X. præstans* had bored $6\frac{1}{2}$ inches into the wood (by actual measurement). The animals are phosphorescent at night."

¹ I first drew attention to this fact in the *Fauna of British India, Mollusca*, vol. ii, 1914, p. 304, and my observations on that occasion have here been embodied.